

**REMARKS**

Applicants thank the Examiner for the very thorough consideration given the present application. Claims 1-3 and 4-10 are currently pending in this application. Claims 5-6 have been withdrawn from consideration. No new matter has been added by way of the present amendment. For instance, the amendments to claims 1 and 7 are supported by the Specification at, for example, page 15, line 22 to page 16, line 1. The amendments to claim 2, as well as new claim 9, are supported by the Specification at page 3, line 25 to page 4, line 8. The amendment to claim 5 is supported by page 36, lines 16-20 of the Specification. New claim 8 finds support at page 37, lines 19-22. New claim 10 is supported by previously presented claim 2. Accordingly, no new matter has been added.

In view of the amendments and remarks herein, Applicants respectfully request that the Examiner withdraw all outstanding rejections and allow the currently pending claims.

**Issues Under 35 U.S.C. § 102(b)/103(a)**

Claims 1-3 and 7 stand rejected under 35 U.S.C. 102(b) as anticipated by or, in the alternative, under 35 U.S.C. 103(a) as obvious over, Andrieu et al. (U.S. 6,261,721) (hereinafter Andrieu '721). Applicants respectfully traverse.

The Examiner asserts that Andrieu '721 teaches a cell separator comprising a microporous matrix, the pores of which contain a microporous polymer. The Examiner further asserts that Andrieu '721 teaches that the microporous polymer has a pore volume in the range of from 35% to 95%, and an average pore diameter of  $0.1\mu\text{m}$  to  $5\mu\text{m}$ . The Examiner also notes that Andrieu '721 teaches that the microporous polymer can be selected from polyvinylidene

fluoride, cellulose polyacetate and polypropylene. The Examiner argues that “[s]ince the microporous polymer is used as a cell separator, it inherently comprises communicating microporous (sic) for required ionic conductivity through the pores”. The Examiner further argues that “since Andrieu teaches a cell separator having the same structure and composition, and made by the same process as the claimed invention, the weight ratio between the microporous polymer and macroporous matrix are deemed to be either anticipated by Andrieu, or obviously provided by practicing the prior art”.

Applicants respectfully submit that the Examiner has failed to establish a *prima facie* case of anticipation. For anticipation under 35 U.S.C. §102, the reference must teach each and every aspect of the claimed invention either explicitly or impliedly. Any feature not directly taught must be inherently present. The fact that a certain result or characteristic may occur or be present in the prior art is not sufficient to establish the inherency of that result or characteristic. *In re Rijckaert*, 9 F.3d 1531, 28 USPQ2d 1955 (Fed. Cir. 1993). To establish inherency, the extrinsic evidence "must make clear that the missing descriptive matter is necessarily present". *In re Robertson*, 169 F.3d 743, 49 USPQ2d 1949 (Fed. Cir. 1999). The mere fact that a certain thing may result from a given set of circumstances is not sufficient. *Id.*

Moreover, Applicants submit that the Examiner has failed to establish a *prima facie* case of obviousness. To establish a *prima facie* case of obviousness, the prior art reference (or references when combined) must teach or suggest all the claim limitations. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991). Additionally, there must be a reason why one of ordinary skill in the art would modify the reference or combine reference teachings to obtain the invention. A patent composed of several elements is not proved obvious merely by

demonstrating that each of its elements was, independently, known in the prior art. *KSR Int'l Co. v Teleflex Inc.*, 82 USPQ2d 1385 (U.S. 2007). There must be a reason that would have prompted a person of ordinary skill in the relevant field to combine the elements in the way the claimed new invention does. *Id.* The Supreme Court of the United States has recently held that the "teaching, suggestion, motivation test" is a valid test for obviousness, albeit one which cannot be too rigidly applied. *Id.* Rejections on obviousness grounds cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness. *Id.*

The present invention is directed, *inter alia*, to a porous film with chemical resistance, comprising a porous film base comprising a multiplicity of communicating micropores having an average pore size of 0.01  $\mu\text{m}$  or more and 5  $\mu\text{m}$  or less and produced by a phase conversion method in which mixtures containing the polymers are cast as films and then introduced to solidifying liquids, and further comprising a chemical-resistant polymeric compound covering the porous film base.

In the present invention, the chemical-resistant polymeric compound or a precursor thereof is used as a solution in a solvent. The solvent is not specifically limited, as long as it can dissolve the polymeric compound or a precursor thereof (see page 26, lines 16 to 20 of Specification). Therefore, a non-solvent is not used in the present invention.

Applicants have discovered that it is possible to obtain a porous film that is excellent in chemical resistance and contains a multiplicity of communicating micropores **while taking advantage of a porous film (base)** (emphasis added), by covering a porous film (base) with a

polymer having excellent chemical resistance, as disclosed on page 3, lines 9-16 of the present Specification.

Thus, in the present invention, a coat of the chemical-resistant polymeric compound or a precursor thereof can be formed, for example, by immersing the film base in the solution, or by spraying or applying the solution to the film base (lines 6 to 13 on page 37 in the present specification). When the formed coat is dried, without any further steps, a coat of the chemical-resistant polymeric compound or a precursor thereof can be formed on the porous film base (see page 38, lines 10 to 12). Therefore, a non-solvent is not used to form the coat of the chemical-resistant polymeric compound or a precursor thereof. Rather, the porous film base of the present invention is produced by a phase conversion method in which mixtures containing the polymers are cast as films and then introduced to solidifying liquids (see, e.g., claim 1).

Present claims 1 and 7 require that the porous film base comprise a multiplicity of communicating micropores having an average pore size of 0.01 $\mu\text{m}$  or more and 5 $\mu\text{m}$  or less. Conversely, Andrieu '721 teaches that the macroporous matrix typically has an initial pore volume in the range of from 35% to 95%, and has pores with an average diameter of from 5 $\mu\text{m}$  to 50 $\mu\text{m}$ , generally in the order of 10 $\mu\text{m}$  (see column 2, lines 25 to 28). Thus, Andrieu '721 does not teach a porous film base as presently claimed.

In addition, present claims 1 and 7 require that the coat of the chemical-resistant polymeric compound covering the porous film base is **not porous** (emphasis added). In the present invention, the coat of the chemical-resistant polymeric compound covering the porous film base is prepared without using a phase inversion technique. This means that the coat is

prepared without immersing the porous film base in a non-solvent that is miscible with the solvent in which the chemical-resistant polymeric compound or a precursor thereof is dissolved. Therefore, the coat of the chemical-resistant polymeric compound covering the porous film base of the present invention is not porous.

In stark contrast, Andrieu's microporous polymer is preferably prepared using the phase inversion technique (see column 2, lines 66 to 67). Andrieu '721 teaches that "[i]n a first embodiment, which operates by immersion, the method of making the separator of the cell in accordance with the invention comprises the following steps: a solution of said polymer dissolved in a solvent, possibly with additives, is produced; said macroporous matrix is impregnated with said solution; **the impregnated matrix is immersed in a non-solvent that is miscible with said solvent;** and said impregnated matrix is dried to eliminate said solvent and said non-solvent. In a second embodiment, which operates by evaporation, the method of making the separator of the cell in accordance with the invention comprises the following steps: a solution of said polymer dissolved in a solvent, possibly with additives, is prepared, said solution further containing a non-solvent that is miscible with said solvent, in a proportion that is insufficient to precipitate said polymer; said macroporous matrix is impregnated with said solution; and said macroporous matrix is dried to eliminate said solvent and said non-solvent" (see column 3, lines 1 to 24). Evidently, Andrieu '721 fails to teach or suggest a non-porous coat of a chemical-resistant polymeric compound covering a porous film base, and rather teaches the use of a microporous polymer.

As noted above, one of the inventive features of the present invention is the ability to obtain a porous film that is excellent in chemical resistance and contains a multiplicity of

communicating micropores while taking advantage of a porous film (base). As noted above, Andrieu '721 teaches that the microporous polymer typically has a pore volume in the range of from 35% to 95% and has pores with an average diameter in the range from 0.1 $\mu$ m to 5 $\mu$ m (column 2, lines 3 to 6). Andrieu '721 further discloses that "[t]he pores or interstices of the matrix and of the polymer have average diameters enabling the polymer to occupy the pores or interstices of the matrix. In general, the ratio of the average pore diameter of the macroporous matrix to the average pore diameter of the microporous polymer is in the range from 2 to 50, and this ratio is conventionally in the order of 10" (see column 2, lines 37 to 43).

Evidently, the pores or interstices of the matrix are occupied by the polymer in Andrieu '721. Therefore, the porous structure of the microporous polymer of Andrieu '721 does not maintain the porous structure of the macroporous matrix. Therefore, Andrieu's separator does not take advantage of the macroporous matrix (i.e., the porous film base).

Conversely, in the present invention, the pores or interstices of the porous film base are coated by a chemical-resistant polymeric compound, and are not occupied by the chemical-resistant polymeric compound, such that the presently claimed porous structure of the porous film is able to maintain the porous structure of the porous film base.

Present claim 2 (as well as newly added claim 10) requires that the chemical-resistant polymeric compound is at least one selected from the group consisting of phenolic resins, urea resins, melamine resins, benzoguanamine resins, polyimide resins, epoxy resins, benzoxazine resins, polyurethane resins, alkyd resins, phthalic resins, maleic resins, silicone resins, triazine resins, furan resins, polyester resins, xylene resins, poly(vinyl alcohol)s, ethylene/vinyl alcohol copolymers, chitins, and chitosans. Andrieu '721 does not teach or suggest these materials.

Example 14

In Example 14, the raw material ("Porous Film Base 1"), which was used as the porous film base, comprised an amide-imide polymer and had an average pore size of about 1.1  $\mu\text{m}$  and an inner porosity of 70%. The amount of the coating phenolic resin (a chemical-resistant polymeric compound) was about 11 percent by weight of the resulting porous film.

(i) The volume of 1g of the porous film base is calculated on the basis of the density of a polyamide-imide of 1.45 g/cm<sup>3</sup> to be 0.67 cm<sup>3</sup> ( $1\text{g} \div 1.45 \text{ g/cm}^3$ ). The total volume of the pores in 1g of the porous film base is calculated on the basis of 70% of inner porosity as 0.48 cm<sup>3</sup> ( $0.67 \text{ cm}^3 \times 0.7$ ). The total volume of the pores is represented by the formula,  $4/3 \pi r^3 \times n$ , wherein r is an average pore radius, and n is a number of pores in 1g of the porous film base.

(ii) The average pore radius r as calculated on the basis of the average pore size of about 1.1  $\mu\text{m}$  is 0.55  $\mu\text{m}$ . The total surface area of pores, represented by the formula  $4\pi r^2 \times n$ , is calculated by using the formula: (total volume of the pores)  $\times 3/r$ , to be  $2.6 \times 10^4 \text{ cm}^2$  ( $0.48 \text{ cm}^3 \times 3/(0.55 \mu\text{m})$ ).

(iii) The weight of the coating phenolic resin (the chemical-resistant polymeric compound) in 1g of the resulting porous film is calculated on the basis of about 11 percent by weight of the amount of the coating phenolic resin to the resulting porous film. The result is 0.11g. The volume of the coating phenolic resin in 1g of the resulting porous film, as calculated on the basis of the density of a phenolic resin of 1.2 g/cm<sup>3</sup>, is 0.09 cm<sup>3</sup> ( $0.11\text{g} \div 1.2 \text{ g/cm}^3$ ). The thickness of the coating phenolic resin is calculated as  $0.09\text{cm}^3 \div (2.6 \times 10^4 \text{ cm}^2) = 0.03 \times 10^{-4} \text{ cm} = 0.03 \mu\text{m}$ .

As shown above, in the present invention, the thickness of the coating layer is extremely thin. In Example 14, the average pore size of the porous film base is 1.1  $\mu\text{m}$ , and the average pore size of the porous film coated by the chemical-resistant polymeric compound is 1.04  $\mu\text{m}$  (1.1 - 0.03  $\times$  2).

Andrieu '721 discloses: "The pores or interstices of the matrix and of the polymer have average diameters enabling the polymer to occupy the pores or interstices of the matrix. In general, the ratio of the average pore diameter of the macroporous matrix to the average pore diameter of the microporous polymer is in the range from 2 to 50, and this ratio is conventionally in the order of 10" (see column 2, lines 37-44 in Andrieu '721). Further, Andrieu '721 teaches that "[t]he polymer concentration is one of the parameters that condition the final porosity" (see column 3, lines 49-51 in Andrieu).

Clearly, as noted above, the porous film of the present invention can maintain the properties of the porous film base without deterioration. Andrieu '721 does not teach or suggest this benefit.

Clearly, Andrieu '721 fails to teach or suggest each and every limitation of the present invention. Accordingly, reconsideration and withdrawal of this rejection are thus respectfully requested.

### Conclusion

All of the stated grounds of rejection have been properly traversed, accommodated, or rendered moot. Applicants therefore respectfully request that the Examiner reconsider all

presently outstanding rejections and objections and that they be withdrawn. It is believed that a full and complete response has been made to the outstanding Office Action and, as such, the present application is in condition for allowance.

Should there be any outstanding matters that need to be resolved in the present application, the Examiner is respectfully requested to contact Vanessa Perez-Ramos, Reg. No. 61,158, at the telephone number of the undersigned below, to conduct an interview in an effort to expedite prosecution in connection with the present application.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37.C.F.R. §§1.16 or 1.147; particularly, extension of time fees.

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# **SYNTHETIC POLYMERIC MEMBRANES**

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**Second Edition**

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IRVINE, CALIFORNIA**

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# 7 PHASE-INVERSION MEMBRANES

*Phase inversion* refers to the process by which a polymer solution (in which the solvent system is the continuous phase) *inverts* into a swollen three-dimensional macromolecular network or gel (where the polymer is the continuous phase). In thin-film form designed for use as a barrier layer, such a gel constitutes a *phase-inversion membrane*.

## 7.1 MECHANISM OF PHASE INVERSION

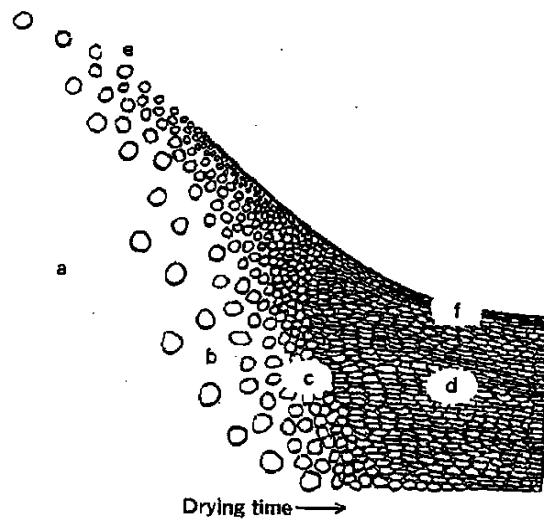
Phase inversion either begins with a molecularly homogeneous single-phase solution (Sol 1) which at some point prior to gelation undergoes a transition into a heterogeneous solution of molecular aggregates consisting of two interdispersed liquid phase (Sol 2), or it begins directly with Sol 2.

In other words, there are two possible reaction sequences for phase inversion:

- (1) Sol 1 → Sol 2 → Gel or
- (2) Sol 2 → Gel

The essence of phase inversion is the appearance in a polymer solution of two interdispersed liquid phases followed by gelation (Fig. 7.1).

The micellar structure which exists in the primary gel, that is, the gel which exists immediately following the Sol 2 → gel transition, differs only infinitesimally from that of Sol 2 just prior to gelation. Therefore, since the structures of Sol 2 and of the primary gel are virtually identical, Sol 2 is conceded structural as well as temporal primacy over the gel.<sup>2</sup> In other words, the structure and function of the final phase-inversion membrane is primarily controlled by adjustments to the Sol 2 structure and only secondarily by modification of the primary gel once the latter has formed.



**FIGURE 7.1.** Mechanism of formation of phase-inversion membranes: (a) Sol 1; (b) Sol 2; (c) primary gel; (d) secondary gel; (e) air-solution interface; (f) skin (adapted from Kesting<sup>1</sup>).

The dispersed phase of Sol 2 consists of spherical droplets or micelles which are coated with polymer molecules. The composition in the interior of the micelles and in the continuous phase will differ from case to case and depends upon the nature of whatever variation of the phase-inversion process is being employed. The reader may find it helpful at this junction to consider the phenomenological model originally developed by Cahn<sup>3</sup> to describe the two-phase structures of metal alloys and more recently also used in conjunction with polymer blends. This model explains the appearance of isotropic interdispersed domains in terms of the decomposition of the *spinodal*, that is, the metastable region of the polymer volume fraction versus temperature curve and yields some insight into the reasons why *uphill* diffusion, that is, diffusion against the concentration gradient, occurs in phase-inversion solutions. Sol 2 is present when some factor either promotes separation into two phases from one phase and/or prevents two phases from recombining into a single phase. It is expedient to entitle this factor *incompatibility*, and to discuss the subdivisions of the phase-inversion process in terms of the various reasons for incompatibility. In the sections to follow, four phase-inversion processes are discussed: the *dry* process, the *wet* process, the *thermal* process, and the *polymer-assisted* process.

## 7.2 THE DRY PROCESS

The *dry* or *complete evaporation* process is the oldest and easiest to interpret of the phase-inversion processes. It can be followed by reference to a typical cellulose nitrate (CN) casting solution (Fig. 7.2a). Final membrane thickness is only a frac-